PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-044941
(43)Date of publication of application : 08.02.2002

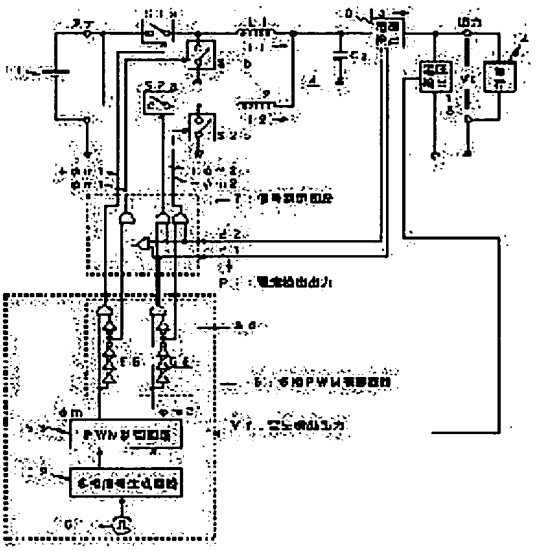
(51)Int.Cl. H02M 3/155

(21)Application number : 2000-227730
(22)Date of filing : 27.07.2000

(71)Applicant : FDK CORP
(72)Inventor : SHIBATA TOSHIO
SUZUKI KATSUMI

(54) DC-DC CONVERTER

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a conversion output of excellent quality and high efficiency having few ripples, in a wide dynamic range from a small to a large current in a DC-DC converter of a switching-control system.
SOLUTION: By switching on/off a plurality of switching circuits S1a, S1b, S2a and S2b with the same cycle and in a different phase with each other, switching frequency at a large-current output is increased effectively, while the number of switching circuits operating at a small-current output is decreased.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Two or more switching circuits which turn on/control [off] at each the input current supplied from common input power, To each the current by which ON / off control was carried out in each switching circuit Composition and the smoothing circuit which carries out smooth and which is supplied to a load, While turning on/off operating mutually two or more above-mentioned switching circuits with the same period and a different phase In the DC-DC converter of the switching control method which has the polyphase PWM control circuit which carries out feedback control of the ON time amount width of face of each switching circuit so that the output voltage of the above-mentioned smoothing circuit may serve as predetermined desired value The DC-DC converter characterized by having the control means of operation to which the subtrahend of the switching circuit which forms ON / off energization way of an input current is carried out at the time of a low current output.
[Claim 2] In a DC-DC converter according to claim 1, said control means of operation is characterized by being constituted by a current detection means to detect the output current supplied to a load from said smoothing circuit, and the signal-control circuit which controls the PWM signal given to said two or more switching circuits based on the detection output of the above-mentioned current detection means from said polyphase PWM control circuit.
[Claim 3] In a DC-DC converter according to claim 1 or 2, said smoothing circuit is characterized by being constituted by two or more inductance components connected to each output side of two or more of said switching circuits at the serial, respectively, and the common capacitative element which collects each passage currents of two or more of these inductance components, and is charged.
[Claim 4] It is characterized by preparing the fly wheel circuit which carries out circulation regeneration of the inertia induced current produced when the energization to said inductance component is intercepted by each output side of two or more of said switching circuits in a DC-DC converter given in either of claims 1-3, respectively.
[Claim 5] In a DC-DC converter according to claim 4, said fly wheel circuit is characterized by being formed of the switching circuit which forms ON / off energization way of an input current, and the switching circuit which carries out ON / off actuation complementary.
[Claim 6] In a DC-DC converter according to claim 5, it is characterized by having a timing adjustment means to make a predetermined offset period intervene between the "on" period of the switching circuit which forms ON / off energization way of an input current, and the "on" period of the switching circuit which forms a fly wheel circuit.
[Claim 7] In a DC-DC converter according to claim 5 or 6, said control means of operation is characterized by always setting the switching circuit which forms a fly wheel circuit as off non-operating state at the time of a low current output.
[Claim 8] In a DC-DC converter given in either of claims 1-7, it is characterized by constituting said switching circuit using an MOS transistor.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is applied to the DC-DC converter for pressure lowering used in order to obtain the DC power supply of a low-battery high current, concerning the DC-DC converter of a switching control method, and is an effective technique.
[0002]
[Description of the Prior Art] For example, in order to time improvement in the speed of operation, without increasing power consumption, what [the latest microprocessor's] operates by the low-battery high current has increased. In the scene which supplies the power source of such low-battery high currents of operation from the comparatively high-pressure power source of a lithium cell etc., the DC-DC converter of a switching control method is suitable.
[0003] This DC-DC converter carries out feedback control of the ON time amount width of face (or duty ratio) of the above-mentioned switching circuit so that the output voltage of that smoothing circuit may turn into a predetermined target electrical potential difference, while making it input into a smoothing circuit, turning on/off controlling an input current in a switching circuit.
[0004] In this DC-DC converter, it is required that the conversion efficiency of an electrical potential difference is good and that there are few ripple components by which it is contained in an output. About a ripple, there is an inclination which becomes large as the output current becomes large. In order to obtain little good conversion output of a ripple also at the time of a high current output, it is effective to make a switching frequency high. However, if the switching periodicity is made high, rebellion that the rate of the power loss accompanying switching operation increases, and conversion efficiency falls will arise.
[0005] The drive loss and switching loss in switching elements, such as an MOS transistor which constitutes a switching circuit, are produced intensively in the transition stage when ON/OFF changes. If a switching frequency is made high, the time amount rate of the transition stage will increase, and conversion efficiency will fall.
[0006] Then, even if the switching frequency in each switching circuit is low by dividing the above-mentioned switching circuit into plurality, and carrying out multiplex composition of the ON / the off output current of each division switching circuit while carrying out polyphase actuation of each division switching circuit with a mutually different phase, the technique which acquired ripple depressor effect equivalent to having switched on the high frequency substantially is offered (for example, JP,53-83014,A, JP,58-136266,A).
[0007] Drawing 5 shows the example of a configuration of the DC-DC converter which divided the switching circuit into plurality. Two switching circuits S1 and S2 which turn on/control [off] at each the input current which the DC-DC converter shown in this drawing forms the direct-current pressure-lowering equipment of a non-insulating mold, and is supplied from the common input power 1, The smoothing circuit 2 which carries out smooth and which is supplied to a load 3 while carrying out multiplex composition of the current i1 by which ON / off control was carried out in each switching circuits S1 and S2 at each, and i2, It is constituted by the electrical-potential-difference detector 4 which detects the output voltage Vo of this smoothing circuit 2, and the polyphase PWM control circuit 5 which controls ON / off actuation of the above-mentioned switching circuits S1 and S2 based on the detection output Vf of this electrical-potential-difference detector 4. The polyphase PWM control circuit 4 carries out feedback control of the ON time amount width of face (pulse energization width of face) of each switching circuits S1 and S2 so that output voltage Vo may serve as

predetermined desired value, while turning on/off operating mutually two or more above-mentioned switching circuits S1 and S2 with the same period and a phase different 180 degrees (polyphase actuation).
[0008] According to this 2 circuit division switching method (two circuit systems), the same ripple depressor effect as having switched on the frequency in each switching circuits S1 and S2 twice the frequency of switching can be acquired. Thereby, little good conversion output of a ripple can be obtained efficiently, without reducing conversion efficiency. In addition, the example of a configuration of drawing 5 is the circuit which this invention persons examined, and is not the conventionally well-known technique itself.
[0009]
[Problem(s) to be Solved by the Invention] However, the technique mentioned above was effective only at the high current output time, at the time of a low current output, the improvement effect of the conversion efficiency by dividing a switching circuit and carrying out polyphase actuation was not acquired, but to cause decline in conversion efficiency was rather shown clearly by this invention person.
[0010] That is, although two circuit systems mentioned above were effective in the improvement in conversion efficiency and ripple control at the time of a high current output, when its attention was paid to the conversion efficiency at the time of a low current output, it became clear that it is more disadvantageous than 1 circuit switching method before it (one circuit system). When it inquires under the premise of both acquiring the same ripple depressor effect, in the case of two circuit systems, at the time of a high current output Although it can be made smaller than the power loss which produces the power loss produced by making each carry out ON/OFF actuation of the two switching circuits by making a switching frequency high and conversion efficiency can be raised The size relation will be reversed at the time of a low current output, and conversion efficiency will fall rather than one circuit system.
[0011] This invention was made in view of the above problems, and that purpose is in offering the DC-DC converter which can obtain little good conversion output of a ripple efficient with the large dynamic range from low current to a high current.
[0012]
[Means for Solving the Problem] As The means for solving a technical problem mentioned above, the following means are offered by this invention. Namely, two or more switching circuits which turn on/control [off] at each the input current supplied from common input power in this invention, To each the current by which ON / off control was carried out in each switching circuit Composition and the smoothing circuit which carries out smooth and which is supplied to a load, While turning on/off operating mutually two or more above-mentioned switching circuits with the same period and a different phase In the DC-DC converter of the switching control method which has the polyphase PWM control circuit which carries out feedback control of the ON time amount width of face of each switching circuit so that the output voltage of the above-mentioned smoothing circuit may serve as predetermined desired value It is characterized by having the control means of operation to which the subtrahend of the switching circuit which forms ON / off energization way of an input current is carried out at the time of a low current output.
[0013] According to the above-mentioned means, the power loss produced by making each turn on/off operate two or more switching circuits at the time of a high current output While being able to make it smaller than the power loss produced by making a switching frequency high and being able to raise conversion efficiency reducing the generation source of the above-mentioned power loss at the time of a small current output (at or the time of a fine current output), while ripple depressor effect equivalent to having switched on the high frequency substantially can be acquired -- **** -- decline in conversion efficiency is avoidable. Thereby, little good conversion output of a ripple can be obtained efficient with the large dynamic range from low current to a high current.
[0014] In the above-mentioned means, a current detection means to detect the output current supplied to a load, and the signal-control circuit which controls the PWM signal given to two or more switching circuits based on the detection output of the above-mentioned current detection means from a polyphase PWM control circuit can constitute a control means of operation from a smoothing circuit.
[0015] Two or more inductance components (choke coil) connected to the serial at each output side of two or more switching circuits, respectively and the common capacitative element which collects each passage currents of two or more of these inductance components, and is charged can constitute the above-mentioned smoothing circuit. In this case, the use effectiveness of a current can be raised by preparing the fly wheel circuit which

carries out circulation regeneration of the inertia induced current (fly wheel current) produced when the energization to the above-mentioned inductance component is intercepted by each output side of two or more switching circuits, respectively.
[0016] The above-mentioned fly wheel circuit can be formed by the switching circuit which forms ON/OFF energization way of an input current, and the switching circuit made to carry out ON/OFF actuation complementary. In this case, if it has a timing adjustment means to make a predetermined offset period intervene between the "on" period of the switching circuit (energization switching circuit) which forms ON/OFF energization way of an input current, and the "on" period of the switching circuit (short circuit switching circuit) which forms a fly wheel circuit, the penetration current which flows when both the switching circuits of energization and a short circuit carry out coincidence ON can be prevented certainly.
[0017] Moreover, if it has the control means which always sets the switching circuit which forms a fly wheel circuit as the non-operating state of OFF at the time of a low current output, the back flow phenomenon in which the charge charged by the capacitative element of a smoothing circuit will discharge through the switching circuit can be prevented certainly.
[0018] An MOS transistor can be used as a switching element which constitutes the above-mentioned switching circuit.
[0019]
[Embodiment of the Invention] Hereafter, the typical operation gestalt of this invention is explained, referring to an accompanying drawing. Drawing 1 shows 1 operation gestalt of the DC-DC converter by this invention. The DC-DC converter shown in this drawing is constituted by two switching circuit S1a, S2a and smoothing circuits 2, the electrical-potential-difference detector 3, the polyphase PWM control circuit 5, the current detector 6, the signal-control circuit 7, etc.
[0020] Switching circuit S1a and S2a turn on/control [off] at each the input current supplied from the common input power 1, such as a lithium ion battery. each -- the current i1 by which was alike in switching circuit S1a and S2a, respectively, and ON / off control was carried out, and i2 are inputted into a smoothing circuit 2, and are assembled. each -- switching circuit (short circuit switching circuit) S1b and S2b which form a fly wheel circuit are connected to the output side of switching circuit (energization switching circuit) S1a and S2a, respectively.
[0021] The inductance components L1 and L2 by which the smoothing circuit 2 was connected to each two output sides, energization switching circuit S1a and S2a, at the serial, respectively, It is constituted by the common capacitative element Co which collects the passage currents (i1, I2) of each inductance components L1 and L2, and is charged, and carrying out multiplex composition of the current i1 by which ON / off control was carried out by switching circuit S1a and S2a, and i2, smooth is carried out and a load 4 is supplied.
[0022] The polyphase PWM control circuit 5 is constituted by the reference frequency signal generating circuit 51, the polyphase signal generation circuit 52, the PWM control circuit 53, the complementary signal generation circuit 54, etc. While turning on/off operating mutually the two above-mentioned switching circuit S1a and S2a with the same period and a phase different 180 degrees based on the detection output Vf of the electrical-potential-difference detector 3, the output voltage Vo of the above-mentioned smoothing circuit 2 serves as predetermined desired value -- as -- each -- feedback control of the ON time amount width of face of switching circuit S1a and S2a is carried out.
[0023] The polyphase PWM control circuit 5 in this case, by the above-mentioned complementation signal generation circuit 54 The above-mentioned energization switching circuits S1 and a, the non-inverter PWM signal +phim1 which turns on/operates [off] S2a by phase reference about 180 degrees, and +phim2, The opposition PWM signal -phim1 which turns on/operates [off] the above-mentioned short circuit switching circuit S1b and S2b complementary to the above-mentioned energization switching circuit S1a and S2a, and -phim2 are outputted. An offset period (d) which the period when both switching circuits (S1a, S1b and S2a, and S2b) of both become off produces by the delay circuit 55 for timing adjustment in the above-mentioned complementation signal generation circuit 54, respectively is inserted in the PWM signal (+phim1, -phim1, +phim2 and -phim2) of the non-inverter and opposition.
[0024] The current detector 6 and the signal-control circuit 7 constitute the control means of operation to which the subtrahend of switching circuit S1a which forms ON / off energization way of an input current, and the S2a is carried out at the time of a low current output. The current detector 6 detects the output current Io supplied to

a load 4 from a smoothing circuit 2. The detection output Pi is outputted in the form of the binary-logic signals d1 and d2 of "1 (yes)" or "0 (low)." the signal-control circuit 7 is constituted using a logic gate -- having -- the above-mentioned detection output Pi (d1, d2) -- being based -- from the polyphase PWM control circuit 5 -- each -- logic control of the effective/the invalid of the PWM signal given to S1b and S2b is carried out to switching circuit S1a and S2a.

[0025] Drawing 2 shows the example of combination of actuation (ON/OFF) / not operating (regular OFF). [of the magnitude of the output current Io, and a switching circuit (S1a, S1b, S2a, S2b)]

[0026] (A) of this drawing divides the output current Io into the three-stage of a high current region, an inside current region, and a small current region, and shows the example which was made to carry out an adjustable setup of actuation / un-operating for every phase. [of a switching circuit (S1a, S1b, S2a, S2b)] in this case, at the time of a high current output, all (S1a, S1b and S2a, and S2b) of 2 sets of switching circuits are turned on/off operated, at the time of an inside current output, only 1 set (S1a, S1b) is operated, and others (S2a, S2b) are always made into the non-operating state of OFF (a usual state -- off). Moreover, at the time of a small current output, the short circuit switching circuit (S1b, S2b) which forms a fly wheel circuit is not operated, and operates only one energization switching circuit (S1a) which forms ON / off energization way. Thereby, polyphase switching operation is performed only at the time of the high current output to which a ripple becomes large, and it controls effectively the ripple which becomes large at the time of a high current output.

[0027] (B) of this drawing divides the output current Io into four steps, a high current region, an inside current region, a small current region, and a fine current region, and shows the example which was made to carry out an adjustable setup of actuation / un-operating (usual state OFF) for every phase. [of a switching circuit (S1a, S1b, S2a, S2b)] In this case, at the time of a high current output, all (S1a, S1b and S2a, and S2b) of 2 sets of switching circuits are operated, and only an energization switching circuit (S1a, S2a) is turned on/off operated at the time of an inside current output. moreover, at the time of a small current output, only 1 set of switching circuits (S1a, S1b) of energization and a short circuit are operated, and others (S2a, S2b) are always made into the non-operating state of OFF (a usual state -- off). Furthermore, at the time of a fine current output, the short circuit switching circuit (S1b, S2b) which forms a fly wheel circuit is not operated, and operates only one energization switching circuit (S1a) which forms ON/OFF energization way. Thereby, the optimal operating state which can perform little good conversion output of a ripple efficient is automatically set up for every phase.

[0028] Drawing 3 illustrates the wave chart of (B) of operation at the time of (A) and a small current output at the time of a high current output. As shown in (A) of this drawing, at the time of a high current output (at the time of heavy loading), few good conversion output waves of a ripple can be acquired by operating all switching circuits (S1, S1b, S2a, S2b). Moreover, as shown in (B), at the time of a small current output (at the time of a light load), by reducing the number of the switching circuits which carry out ON/OFF actuation, the power loss accompanying ON/OFF actuation of the switching circuit can be reduced, and high conversion efficiency can be maintained. In this drawing, d is an offset period, and the time amount width of face is beforehand set up so that it can prevent certainly that a penetration current flows to switching circuit S1a, S1b and S2a, and S2b, respectively.

[0029] Drawing 4 is the graph shown while making the conversion efficiency property over the output current Io of the DC-DC converter by this invention contrast with the thing of two conventional circuit systems. In the DC-DC converter by this invention, little good conversion output of a ripple can be obtained efficient with the large dynamic range from low current to a high current so that clearly also from this drawing.

[0030] As mentioned above, although this invention was explained based on the typical operation gestalt, various modes are possible for this invention also besides having mentioned above. For example, a fly wheel circuit may be formed using SHOKKI barrier diode. Moreover, it becomes possible to constitute the DC-DC converter of an I/O insulation mold by transposing two or more inductance components L1 and L2 to the division primary winding of a transformer which shares a core and a secondary winding, respectively. Furthermore, although the operation gestalten mentioned above were 2 phase drive methods which carry out ON/OFF actuation of 2 sets of switching circuits by phase reference about 180 degrees, in this invention, the polyphase drive method more than a three phase circuit is also possible.

[0031]

[Effect of the Invention] As explained above, while raising effectually the switching frequency at the time of a

high current output by carrying out ON/OFF actuation of two or more switching circuits with the same period and a different phase mutually, with the DC-DC converter of this invention, little good conversion output of a ripple can be obtained efficient with the dynamic range larger than carrying out the subtrahend of the switching circuit operated at the time of a low current output from low current to a high current.

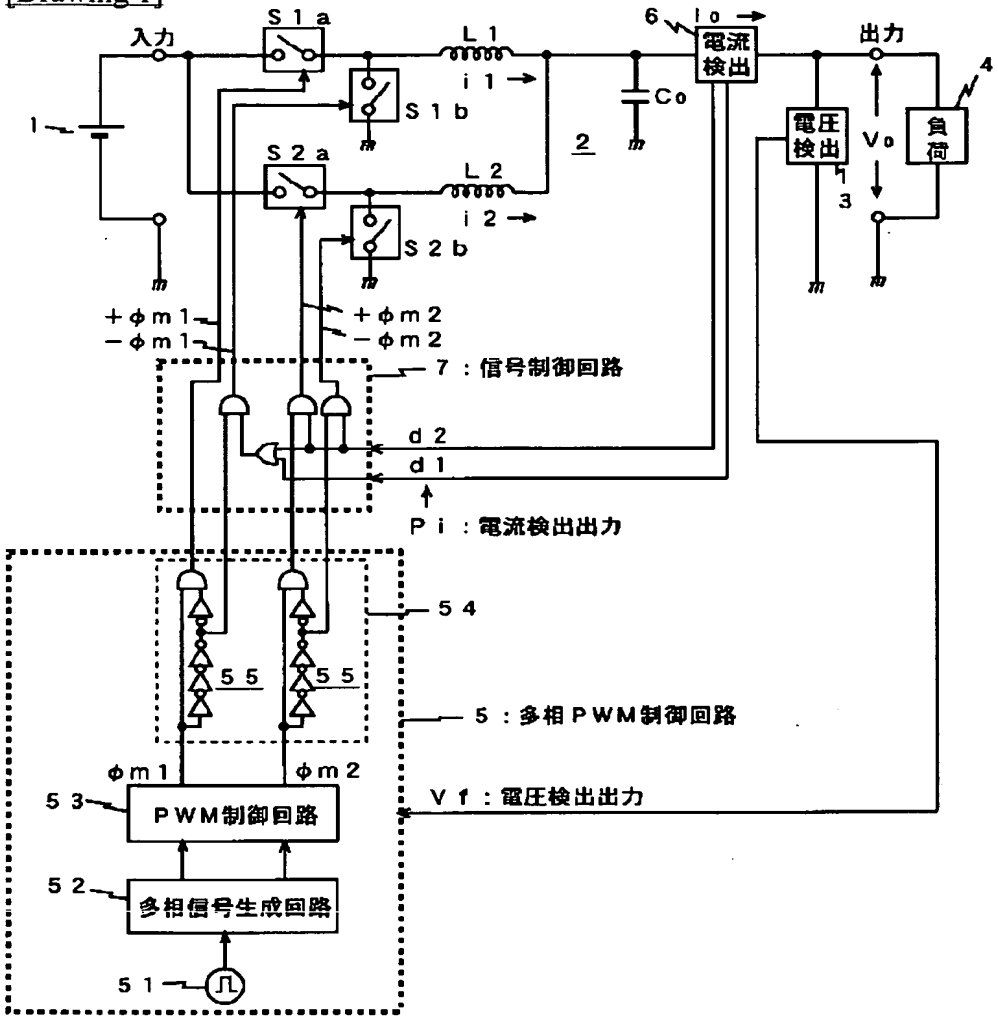
[Translation done.]

* NOTICES *

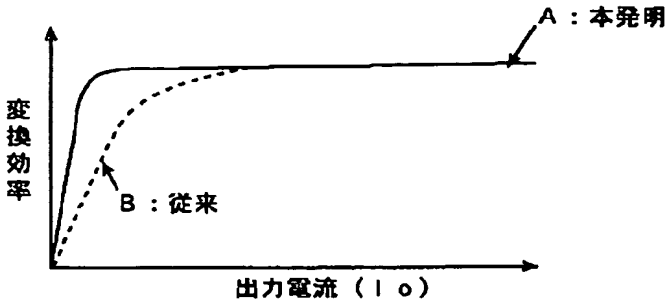
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 4]



[Drawing 2]

（Ａ）出力電流とスイッチング回路の動作組み合わせ例

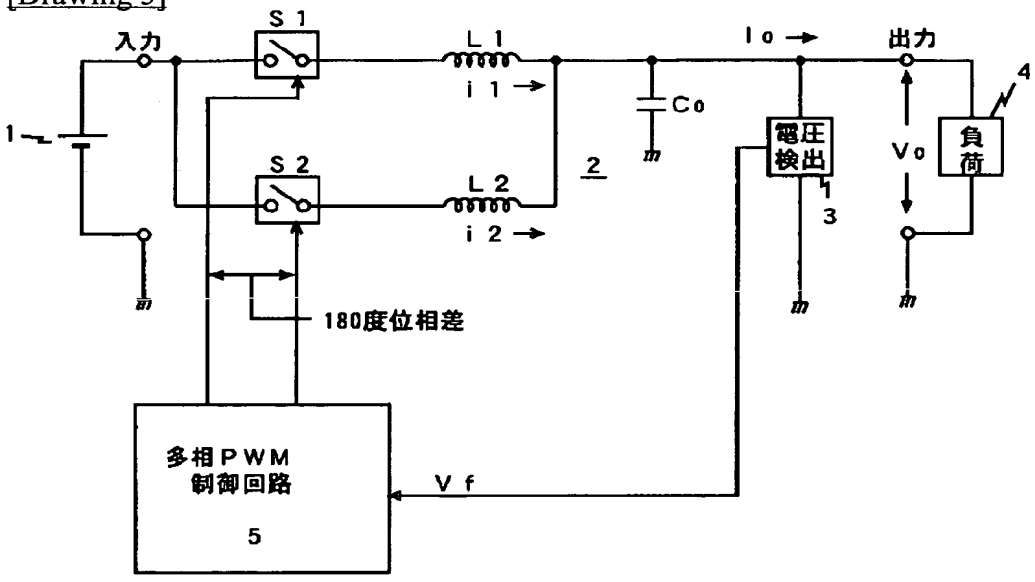
出力電流 Ｉｏ	スイッチング回路			
	Ｓ１ａ	Ｓ１ｂ	Ｓ２ａ	Ｓ２ｂ
大電流域	動作	動作	動作	動作
中電流域	動作	動作	常オフ	常オフ
小電流域	動作	常オフ	常オフ	常オフ

（図１に対応）

（Ｂ）出力電流とスイッチング回路の動作組み合わせ例

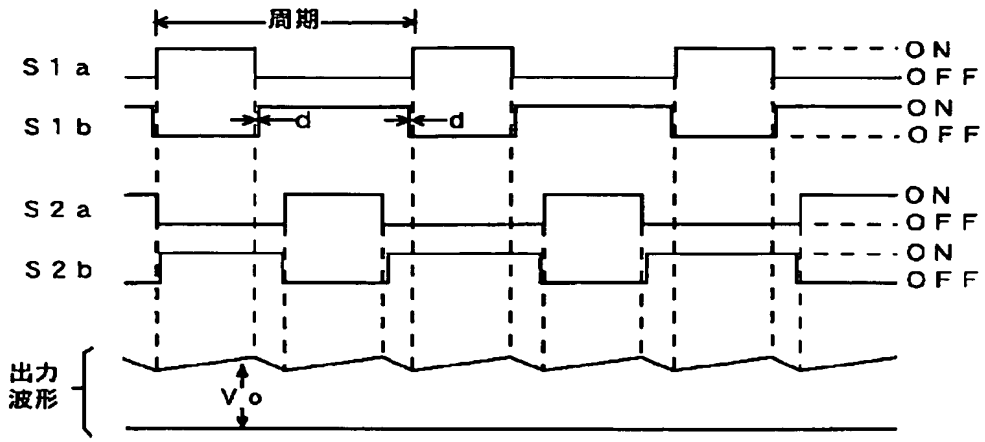
出力電流 Ｉｏ	スイッチング回路			
	Ｓ１ａ	Ｓ１ｂ	Ｓ２ａ	Ｓ２ｂ
大電流域	動作	動作	動作	動作
中電流域	動作	常オフ	動作	常オフ
小電流域	動作	動作	常オフ	常オフ
微電流域	動作	常オフ	常オフ	常オフ

[Drawing 5]

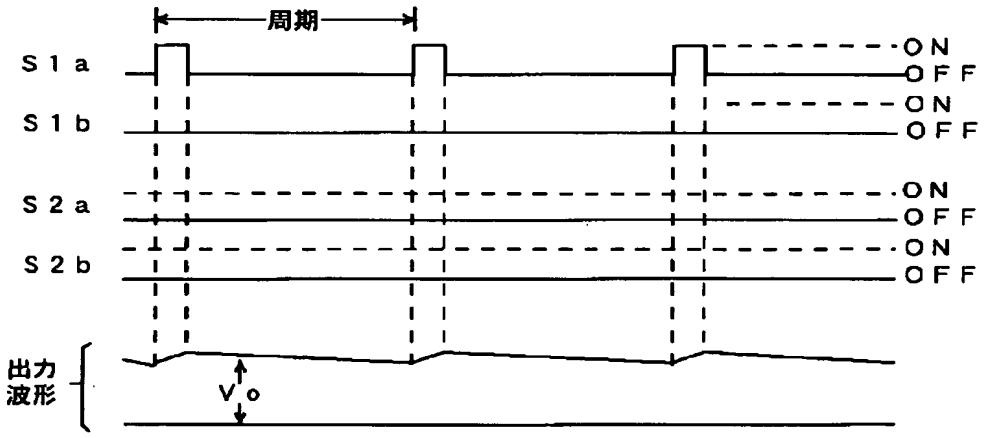


[Drawing 3]

（A） 大電流出力（重負荷）時



（B） 小電流出力（軽負荷）時



[Translation done.]